MARKET OPPORTUNITIES FOR
VLSI COMPUTER-AIDED DESIGN PRODUCTS
VOLUME II

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VOLUME II

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CONTROL DATA CORPORATION

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MARKET OPPORTUNITIES FOR
VLSI COMPUTER-AIDED DESIGN PRODUCTS
VOLUME II

TABLE OF CONTENTS

		Page
I	INTRODUCTION	1
II	SCOPE AND METHODOLOGY	3
	A. Scope	3
	B. Methodology	4
III	EXECUTIVE SUMMARY	7
	A. VLSI Design	7
	B. Human Interface In CAD/VLSI	10
	C. Support Requirements	11
	D. Market Size And Growth	12
	1. By Application	12
	2. By Mode Of Delivery	14
	E. Conclusions	16
	F. Recommendations	16
IV	VLSI DESIGN PROCESS	19
	A. Elements Of VLSI Design	19
	1. Technology	19
	2. Design Process	20
	3. Design Errors And Yield Considerations	22
	4. Most Important CAD Applications	23
	B. Adequacy Of CAD/VLSI Applications	25
	1. Adequacy	25
	2. Expected Changes In The Design Process	29
	C. Machine Time And Labor By Application	32
V	MARKET ANALYSIS AND FORECAST	35
	A. Market Analysis And Forecast By Application	35
	B. Market Analysis And Forecast By Mode Of Delivery	37
	1. Mode Of Delivery	37
	2. Importance Of Overall System Design	41
VI	THE HUMAN INTERFACE IN CAD/VLSI	45
	A. Graphics	45
	B. Color	47
	C. Response Times	49

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		Page
VII	SUPPORT REQUIREMENTS	51
	A. Consulting	51
	B. Independent Design Centers	52
APPENDIX A:	DATA BASE	55
APPENDIX B:	DEFINITIONS	57
APPENDIX C:	QUESTIONNAIRE	65

MARKET OPPORTUNITIES FOR
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VOLUME II

LIST OF EXHIBITS

			Page
II	-1	Interview Program - Users Of CAD/VLSI Systems	5
III	-1	Percent Of User Expenditures For Vendor-Supplied CAD/VLSI Systems By Major Application, 1980-1985, As Reported By Respondents (Includes All Modes Of Delivery)	13
	-2	Percent Breakdown Of User Expenditures For Vendor-Supplied CAD/VLSI Systems By Mode Of Delivery, 1980-1985, As Reported By Respondents	15
IV	-1	Design Process For A Device Equivalent In Complexity To A Microprocessor	21
	-2	Most Important CAD Applications For A Device Equivalent In Complexity To A Microprocessor	24
	-3	Respondents' Ratings Of The Adequacy Of CAD/VLSI Applications - 1980	26
	-4	Respondents' Ratings Of The Adequacy Of CAD/VLSI Applications - 1985	28
	-5	Respondents' Overall Ratings Of The Adequacy Of CAD Applications As A Whole - 1980-1985	30
	-6	Expected Improvements In The CAD/VLSI Design Process, 1980-1985, As Reported By Respondents	31
	-7	Design Labor And Computer Time Expended For A Typical VLSI Design (Microprocessor), Estimated From Varied Responses	33
V	-1	Percent Of User Expenditures For Vendor-Supplied CAD/VLSI Systems By Major Application, 1980-1985, As Reported By Respondents (Includes All Modes Of Delivery)	36
	-2	Percent Of CAD/VLSI Processing Accomplished By Mode Of Delivery For Each Application, 1980-1985, As Reported By Respondents	38
	-3	Breakdown Of User Expenditures For Vendor-Supplied CAD/VLSI Systems By Mode Of Delivery For Each Application, 1980-1985, As Reported By Respondents	40
	-4	Breakdown Of User Expenditures For Vendor-Supplied CAD/VLSI Systems By Mode Of Delivery - Total And AAGR, 1980-1985	42

			Page
VI	-1	Respondents' Ratings Of The Importance Of Graphics For CAD/VLSI Applications	46
	-2	Respondents' Ratings Of The Importance Of Color For CAD/VLSI Applications	48
A	-1	Interview Program - Users Of CAD/VLSI Systems	55
	-2	Breakdown of User Expenditures For Vendor-Supplied CAD/VLSI Systems By Mode Of Delivery - Total And AAGR, 1980-1985	56

1 INTRODUCTION

I INTRODUCTION

- The primary objectives of this study are to determine in greater detail the projected market through 1985 for Computer-Aided Design (CAD) products used for the design of VLSI devices.

- The current CAD/VLSI design process is examined, and designers' perceptions are determined concerning how the process will change by 1985.

- Results of the study are presented in order to identify CAD/VLSI market oppor tunities and business strategies offering the greatest potential for the Control Data Corporation in the 1980-1985 timeframe.

II SCOPE AND METHODOLOGY

II SCOPE AND METHODOLOGY

A. SCOPE

- The research conducted in this report addresses how the market for CAD/VLSI products will be broken down in the 1980-1985 timeframe by:

  - Major applications.
  - Mode of delivery.

- Steps in the design process are detailed, and the most important applications are determined.

- The human interfaces in CAD/VLSI systems are examined, with emphasis on the following:

  - The importance of graphics.
  - The importance of color.
  - Labor and machine time by application.
  - Response times.

- Users' perceived needs for consulting and design center capabilities are determined.

B. METHODOLOGY

- Ten interviews were conducted with VLSI computer-aided design users, primarily located in the "Silicon Valley" of the San Francisco Bay Area. The interview program users of CAD/VLSI Systems are shown in Exhibit II-1.

  - The ten interviews are equally divided between on-site and telephone.

  - All of the interviews were conducted by INPUT senior staff.

  - To obtain a broad cross-section of points of view, the users represented systems companies, computer manufacturers, semiconductor producers and a university.

  - The respondents are all highly knowledgeable of the CAD/VLSI industry.

EXHIBIT II-1

INTERVIEW PROGRAM -
USERS OF CAD/VLSI SYSTEMS

TYPE OF ORGANIZATION	NUMBER OF RESPONDENTS	ON-SITE / TELEPHONE
SYSTEMS COMPANY	2	1 / 1
COMPUTER MANUFACTURER	3	2 / 1
SEMICONDUCTOR PRODUCER	4	1 / 3
UNIVERSITY	1	1 / –
TOTAL	10	5 / 5

III EXECUTIVE SUMMARY

A. VLSI DESIGN

- The research in this study was specifically directed toward the VLSI design process for a product with a complexity equivalent to that of a microprocessor, which means a chip complexity of:

  - 20,000 to 40,000 components per chip in 1980.
  - One million components per chip in 1985.

- The steps in the VLSI design process progress in the following sequence:

  - Specification.
  - Architecture.
  - Chip design.
  - I.C. layout.
  - Fabrication.

- Applications supporting the above sequential steps operate in an interactive mode and consist of the following:

  - Circuit, logic and functional simulation for chip design.

  - Schematics or topography verification, and design rules checking for I.C. layout.

  - Testing and mask modifications for fabrication.

- Design errors generally fall into two categories: architectural and circuit design or layout.

  - Architectural errors are basic and must be corrected by repeating the design process from the beginning.

  - Circuit design or layout errors are corrected by modifying the design of the mask in I.C. layout.

- This study is focused on the most important CAD applications for a device with a complexity equivalent to that of a microprocessor. The major applications were determined to be the following:

  - Design rules checking.

  - I.C. layout.

  - Functional, logic and circuit simulation.

  - Topography verification (schematics).

  - Electrical testing.

- The basic design process as it exists today is not expected to change by 1985. However, dramatic improvements in the adequacy of the applications are expected in order to meet the needs of future VLSI design.

- Today's CAD/VLSI systems are severely inadequate, even for present VLSI complexity levels.

  - They require excessive amounts of design labor and computer time, which, if extrapolated to expected 1985 levels of complexity, clearly would limit industry growth.

- Respondents reflected confidence that three of the five applications would be adequate by 1985.

  - Design rules checking is expected to be built into the computer so that separate runs will no longer be required.

  - I.C. layout and circuit and logic simulation will be greatly improved by advances in software design and improved price performance of hardware.

- Certain key applications cannot be handled by today's CAD systems.

  - Functional simulation is needed, but is not available.

  - Schematics (topography) and testing are vital applications, but users have no solution today.

- The expected major improvements in the CAD/VLSI design process in the forecast timeframe are:

  - Design rules checking.

- Schematics.

- Testing.

- Functional simulation.

- Skill levels of I.C. layout designers.

B. HUMAN INTERFACE IN CAD/VLSI

- Graphics are very important - and will remain so in the forecast timeframe - because of the human interface.

  - CAD/VLSI systems are basically tools to make designers more productive in order to shorten the design span, rather than systems to automate the design process.

- The importance of graphics depends on the application.

  - They are critically important for those applications where a major human interface is involved, like I.C. layout and schematics, and not very important for applications that do not involve a major human interface, like circuit and logic simulation and testing.

- The following applications are ranked in order of the importance of graphics.

RANK	APPLICATION
1	I.C. layout
2	Schematics
3	Design rules checking
4	Circuit and logic simulation
5	Testing

- While graphics are very important for CAD/VLSI systems, they are generally regarded as inadequate today.

  - INPUT believes that graphics are a very important design feature in the forecast timeframe.

- Color is not fundamental, but it is much more than a nicety.

  - Color must be provided in future CAD/VLSI systems in order to be competitive.

  - Any function where the human interface is important, such as layout or error display, color reduces errors and design time.

- Response times are a problem in today's CAD/VLSI systems, and are likely to remain so in the future.

  - The response time problem relates to multiple users operating in a timesharing mode.

  - By entering a major application, one user can slow system response for others, adversely affecting productivity.

C. SUPPORT REQUIREMENTS

- It is essential that users have access to members of the vendor's professional staff who really understand the software.

- It is often difficult for users to get access to, and communicate with, members of the vendor's professional staff remotely.

- Vendor-supplied local professional consulting services would meet with a high degree of user acceptance.

- Users have a decidedly negative attitude toward the concept of independent design centers providing contract services for VLSI products.

  - Users regard an in-house VLSI design capability as essential.

  - Protection of proprietary rights is a problem, particularly now that entire systems can be placed on a single chip.

D. MARKET SIZE AND GROWTH

1. BY APPLICATION

- Percent of user expenditures for vendor-supplied CAD/VLSI systems by major application, 1980-1985, are shown in Exhibit III-1.

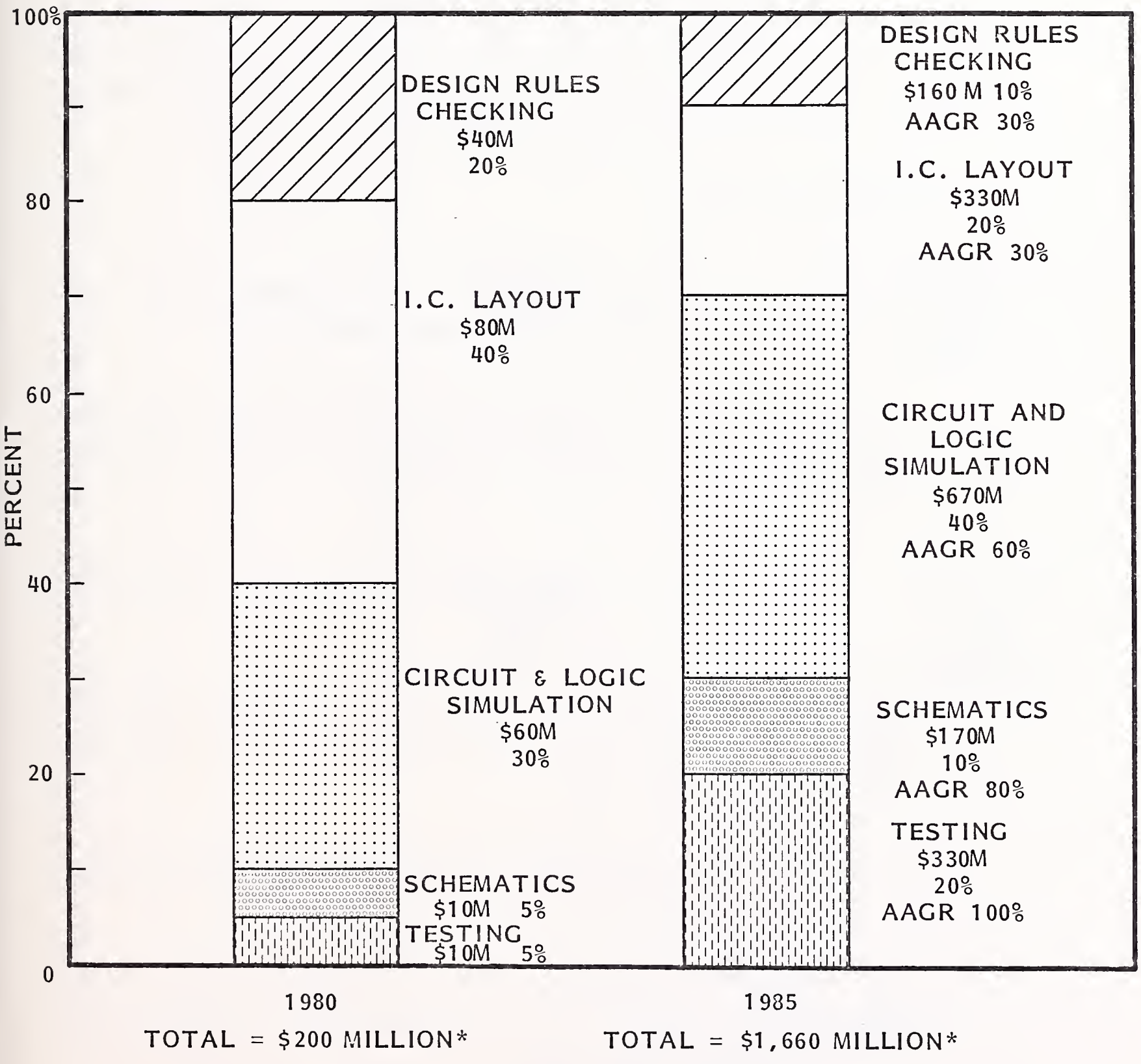
  - The CAD/VLSI total market, including all modes of delivery, is projected to grow at an AAGR of 50% from $200 million per year in 1980 to $1,660 million per year in 1985.

  - Schematics and testing, taken together, are the most rapidly growing applications (AAGR of 90%) and are expected to account for 30% of the market in 1985.

  - Due to very large processing requirements, simulation is expected to grow at an AAGR of 60%, considerably above the growth rate of the industry as a whole, and to account for 40% of the market in 1985.

EXHIBIT III-1

PERCENT OF USER EXPENDITURES FOR VENDOR-SUPPLIED CAD/VLSI SYSTEMS BY MAJOR APPLICATION, 1980-1985, AS REPORTED BY RESPONDENTS (INCLUDES ALL MODES OF DELIVERY)



TOTAL = $200 MILLION*

TOTAL = $1,660 MILLION*

*INPUT FORECAST

- Design rules checking and I.C. layout, which together account for 60% of the market in 1980, are expected to grow at an AAGR of 30%, which is less than the rate for the industry as a whole.

  . These two applications account for 60% of the market in 1980 but are expected to be down to 40% of the market in 1985.

  . This decrease in growth is attributable to the prospect that design rules checking will be accomplished automatically by 1985, and I.C. layout is expected to benefit from improved software and better price performance in equipment.

2. BY MODE OF DELIVERY

- Percent breakdown of user expenditures for vendor-supplied CAD/VLSI systems by mode of delivery, 1980-1985, are shown in Exhibit III-2.

  - Turnkey systems are the predominant mode of delivery in 1980, and are expected to remain so in 1985, accounting for 55% of the market, or $910 million per year in 1985.

    . The AAGR for turnkey systems is expected to be 50%, the same as the industry as a whole.

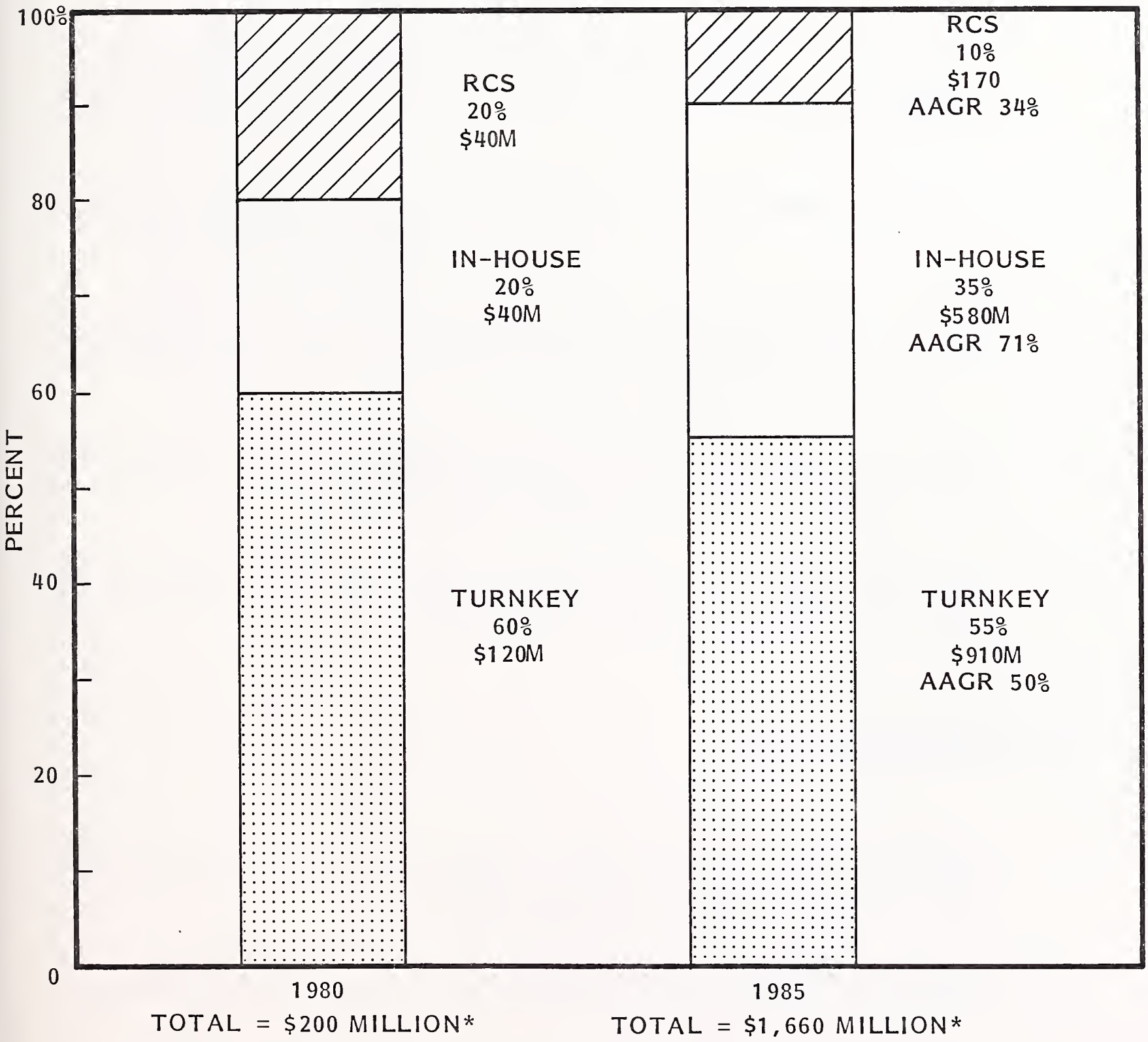
  - In-house systems are expected to be the fastest-growing sector of the market, with an AAGR of 71%, accounting for 35% of the market, or $580 million per year in 1985.

    . Adding new applications on in-house machines rather than on RCS is an important reason for this rapid growth.

  - RCS are expected to grow at an AAGR of 34%, considerably less than the industry as a whole, and account for only 10% of the total market, or $170 million per year in 1985.

EXHIBIT III-2

PERCENT BREAKDOWN OF USER EXPENDITURES FOR VENDOR-SUPPLIED CAD/VLSI SYSTEMS BY MODE OF DELIVERY, 1980-1985, AS REPORTED BY RESPONDENTS



*INPUT FORECAST
T/K = FREESTANDING (TURNKEY) SYSTEMS (MINICOMPUTER-BASED)
I/H = LARGE IN-HOUSE HOST SYSTEMS
RCS = REMOTE COMPUTING SYSTEMS

E. CONCLUSIONS

- All five key applications are essential for CAD/VLSI systems.
- The industry will achieve major advancements in design rules checking, I.C. layout and simulation.
- There will be an urgent need for schematics and testing, which account for only 10% of the market in 1980, but are expected to expand to 30% by 1985, at an AAGR of 90%.
- Graphics are essential and will be greatly improved. Color is a competitive requirement.
- Response time problems will diminish through use of distributed systems and technological improvements.
- Respondents have little interest in design centers; however, they would find local professional consulting capabilities very attractive.
- Respondents expect the in-house growth rate to be 71% (AAGR) at the expense of an RCS growth rate of 34% (AAGR).

F. RECOMMENDATIONS

- Consider providing a turnkey system. Turnkey will represent 55% of the $1,660 million-per-year market for CAD/VLSI in 1985.
- Do not underemphasize the user interface with the system through graphics.

- Evaluate the economics of providing local professional consulting services to CAD/VLSI users.

- Leapfrog applications development by further identifying, specifying and providing solutions for schematics and testing.

IV VLSI DESIGN PROCESS

IV VLSI DESIGN PROCESS

A. ELEMENTS OF VLSI DESIGN

1. TECHNOLOGY

- In examining the steps in the VLSI design process, both as they exist today and how they will differ in 1985, the research was specifically directed toward the VLSI design process for a product with the complexity equivalent to that of a microprocessor. INPUT interprets this to mean a chip complexity level of the following:

  - 20,000 to 40,000 components per chip in 1980.

  - One million components per chip in 1985.

- The one million component chip cannot be achieved with today's CAD/VLSI tools, which threatens to be a basic industry limitation.

  - INPUT believes - and it is a basic premise of this study - that the combined efforts of government, university and industry research efforts will be successful, in the 1980-1985 timeframe, in meeting industry needs for VLSI computer-aided design tools.

2. DESIGN PROCESS

- A flow diagram of the design process for a device equivalent in complexity to a microprocessor is shown in Exhibit IV-1.

  - The steps involved are sequential, progressing from initial specification to final fabrication, but each design step is also interactive with design applications, as shown in the diagram.

  - For today's chip, the design process may take from six to 12 months to accomplish, with refinements in circuit design and layout being made during the entire process.

- The starting point is to define the basic architecture from the system specification.

  - Here, the determination is made as to what part of the system goes on the chip.

  - Relationships are determined with regard to speed, volume, power requirements and partitioning to arrive at the basic floor plan of the chip.

- Chip design is fundamentally a process of software and circuit emulation in the computer.

  - Simulation is required at these levels:

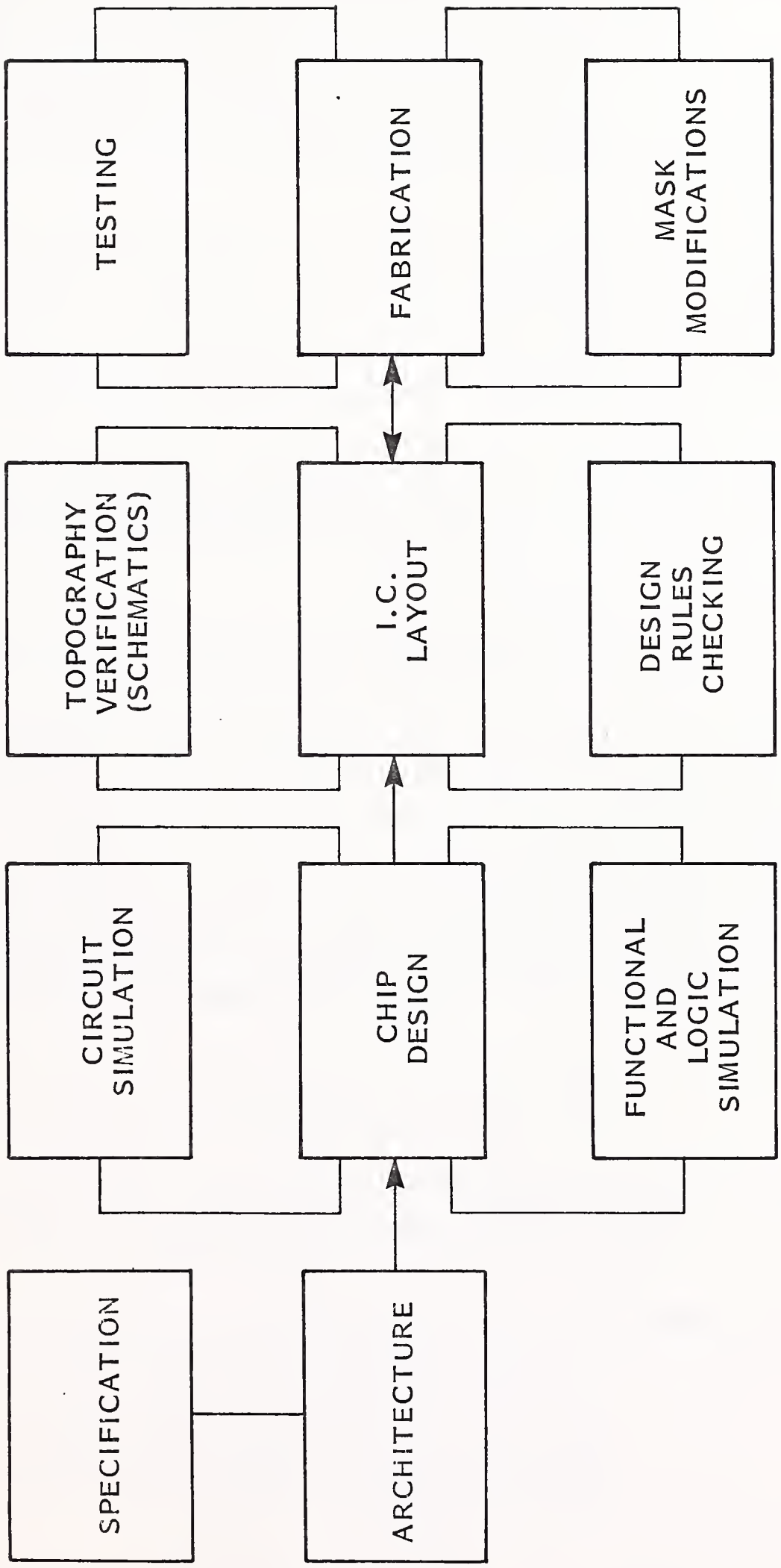
    . Circuit.

    . Logic.

    . Functional.

EXHIBIT IV-1

DESIGN PROCESS FOR A DEVICE EQUIVALENT IN COMPLEXITY TO A MICROPROCESSOR



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- I.C. layout creates the artwork required for mask fabrication.

  - Overall topography is verified by comparing the schematic produced by the computer from the chip, to that initially generated by the design, assisted by the computer.

  - Design rules checking is concerned with physical dimensioning, spacing and layout.

  - Cell design is an important part of I.C. layout.

    . Cells are any groupings that have a definitive structure that can be repeated by a process in the computer allowing creation of its own artwork.

    . The process can be on-line and dynamic.

- The initial fabrication step seeks to determine design errors through rigorous testing.

- The entire CAD/VLSI design process is very labor-intensive and will remain so. One respondent, an executive in a computer manufacturing firm, summed this up in speaking to the director of computer-aided design:

  - "Remember, you are in the design aids business to reduce design time, not in the business of design automation."

3. DESIGN ERRORS AND YIELD CONSIDERATIONS

- Design errors generally fall into two categories.

  - Architectural errors at the system level are infrequent, but when they occur, the correction requires repeating the steps in the design process from the beginning.

- Circuit design or layout errors are corrected by modifying the photomask design in I.C. layout and rerunning design rules checking.

• Yield considerations involve either the malfunction of some percentage of the components on the chip or bad batches caused by problems in the manufacturing process.

- Testing is done to determine the number of nonfunctioning components. Then it is a matter of judgement to determine which course of action to take. There are three possibilities:

  . The chip is acceptable because of the considerable number of redundant circuits.

  . The error is intolerable and must be corrected.

  . The product must be downgraded.

- Another yield consideration is bad lots, generally caused by contamination or other problems in the computer-aided manufacturing process.

  . The measure of this type of yield problem is wafer-sort yield: the number of good chips per wafer.

4. MOST IMPORTANT CAD APPLICATIONS

• The most important CAD applications for a device with a complexity equivalent to that of a microprocessor are shown in Exhibit IV-2.

- Respondents agreed that these five CAD applications accounted for all of the CAD/VLSI process for all practical purposes.

- These categories are used as the focus for this study.

EXHIBIT IV-2

MOST IMPORTANT CAD APPLICATIONS
FOR A DEVICE EQUIVALENT IN COMPLEXITY
TO A MICROPROCESSOR

- DESIGN RULES CHECKING
- I.C. LAYOUT
- FUNCTIONAL, LOGIC AND CIRCUIT SIMULATION
- TOPOGRAPHY VERIFICATION/SCHEMATICS
- ELECTRICAL TESTING

B. ADEQUACY OF CAD/VLSI APPLICATIONS

1. ADEQUACY

- Respondents' ratings of the adequacy of CAD/VLSI applications in 1980 are shown in Exhibit IV-3. Ratings are on a scale where 5 is completely adequate and 1 is woefully inadequate.

  - The ratings for the five major applications, ranging from 1.9 to 3.1, clearly reflect the fact that today's CAD systems for VLSI are severely inadequate even for present VLSI complexity levels.

- One respondent said:

  - "Present CAD/VLSI applications are woefully inadequate, I would vote them a 1; yet major strides have been made. Designs that were taking two years can now be done in six months."

- Present CAD/VLSI systems require excessive amounts of design labor and computer run times, which, if extrapolated to expected 1985 VLSI complexity levels, would clearly limit industry growth.

- Certain key applications cannot be handled by today's CAD systems.

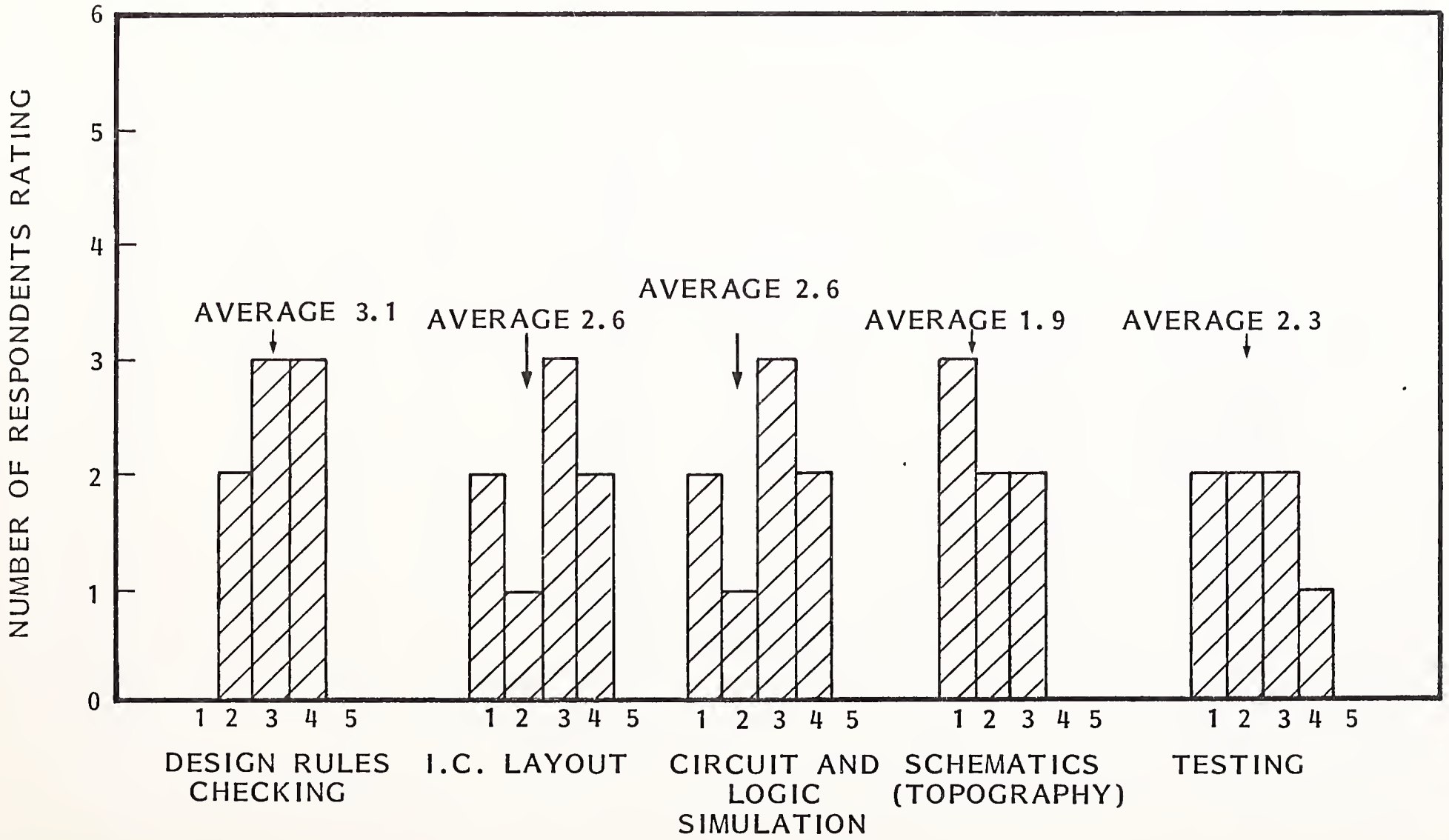
  - Functional simulation is needed but not available.

  - Schematics (topography) and testing are vital, but users see no solution today.

- Respondents were asked to rank the five applications in order of importance, but none of the respondents was able to do so.

EXHIBIT IV-3

RESPONDENTS' RATINGS OF THE
ADEQUACY OF CAD/VLSI APPLICATIONS -
1980



NOTE: RATED ON SCALE WHERE 5 IS COMPLETELY ADEQUATE AND 1 IS WOEFULLY INADEQUATE

- The five applications represent a "core cadre" and are all vitally needed, so relative importance is not meaningful.

- Respondents' ratings of the adequacy of CAD/VLSI applications in 1985 are shown in Exhibit IV-4.

  - The relatively high ratings (3.8 - 4.9) respondents gave to design rules checking, I.C. layout, and circuit and logic simulation, and the great uniformity of the repondents' ratings, reflect a high level of confidence that continued research and development will yield solutions for these applications in the 1985 timeframe.

  - This same confidence and uniformity of ratings does not extend to schematics and testing because solutions are not evident for these two vital applications, nor are they receiving much attention.

- Needed improvements in CAD methods for 1985 VLSI technology cannot be accomplished by "brute force" methods, but rather from new ways of doing things coming from research and development efforts.

  - Design rules checking is expected to be built into the computer system so that designs are automatically constrained to be in conformity with design rules, and no separate DRC runs are required.

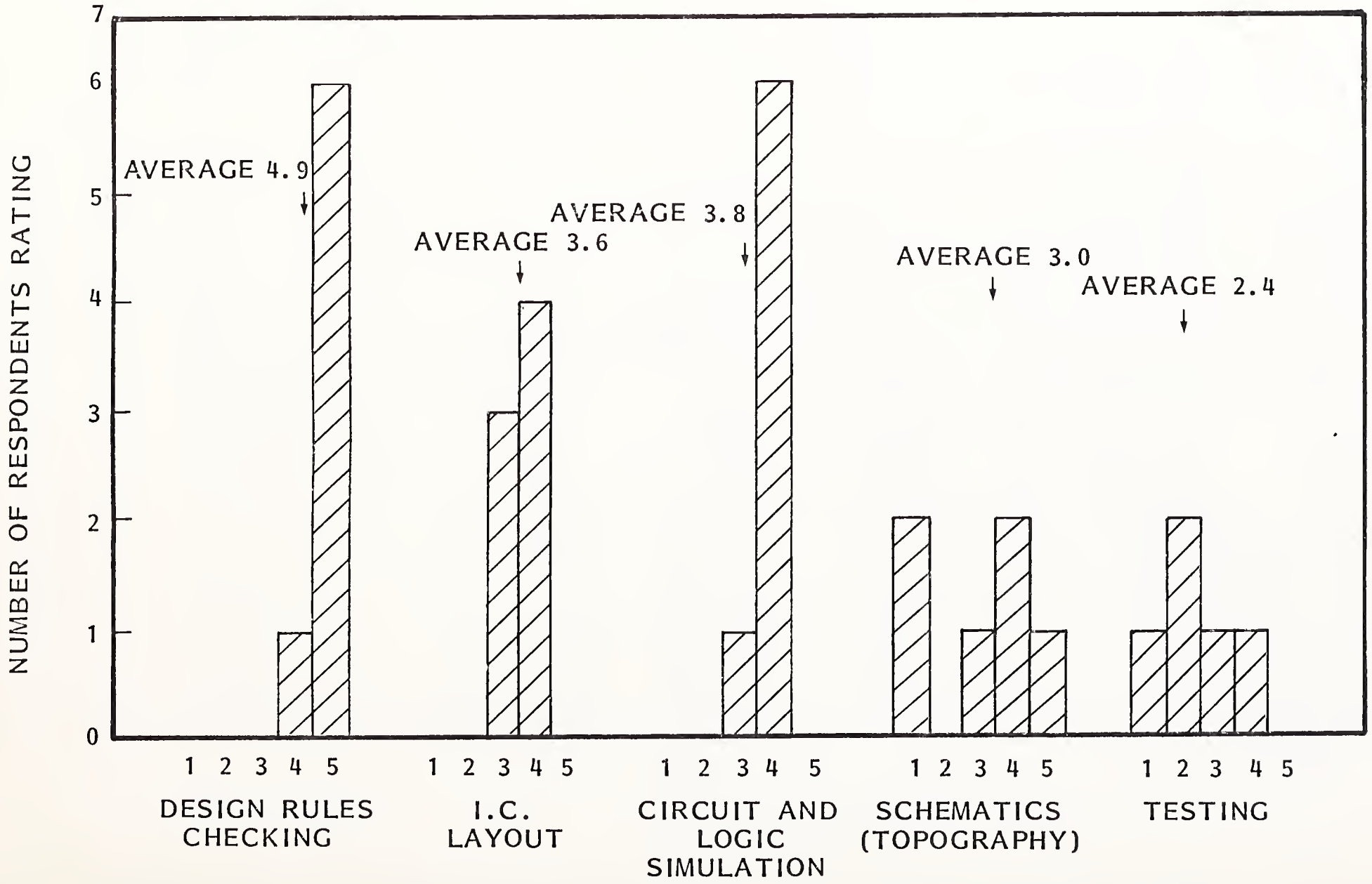
  - Needed improvements in I.C. layout and circuit and logic simulation are expected to come from new methods, research in software and improved price performance in hardware.

  - Schematics, or topography verification, have received little attention to date but are vitally needed for future VLSI devices.

    . These are prime candidates for research and development efforts.

EXHIBIT IV-4

RESPONDENTS' RATINGS OF THE
ADEQUACY OF CAD/VLSI APPLICATIONS-
1985



NOTE: RATED ON A SCALE WHERE 5 IS COMPLETELY ADEQUATE AND 1 IS WOEFULLY INADEQUATE.

- Testing needs to be done at the component level, but is presently done at the systems level.

  . No one knows how to do it at a more detailed level, or even how to define what testing should be done.

  . Testing is also a prime candidate for research and development efforts.

- In summary, respondents' overall ratings of the adequacy of CAD applications as a whole are shown in Exhibit IV-5.

  - The above-average rating in 1985 generally reflects users' confidence that improved CAD methods will be able to keep pace with the enormous growth expected in VLSI complexity by 1985.

2. EXPECTED CHANGES IN THE DESIGN PROCESS

- The basic computer-aided design process is not expected to change materially between 1980 and 1985, but the applications are expected to be greatly improved in the forecast timeframe.

  - When asked whether they expected the present CAD/VLSI process to change materially from 1980 to 1985, seven out of eight respondents replied "no," but all expected major improvements.

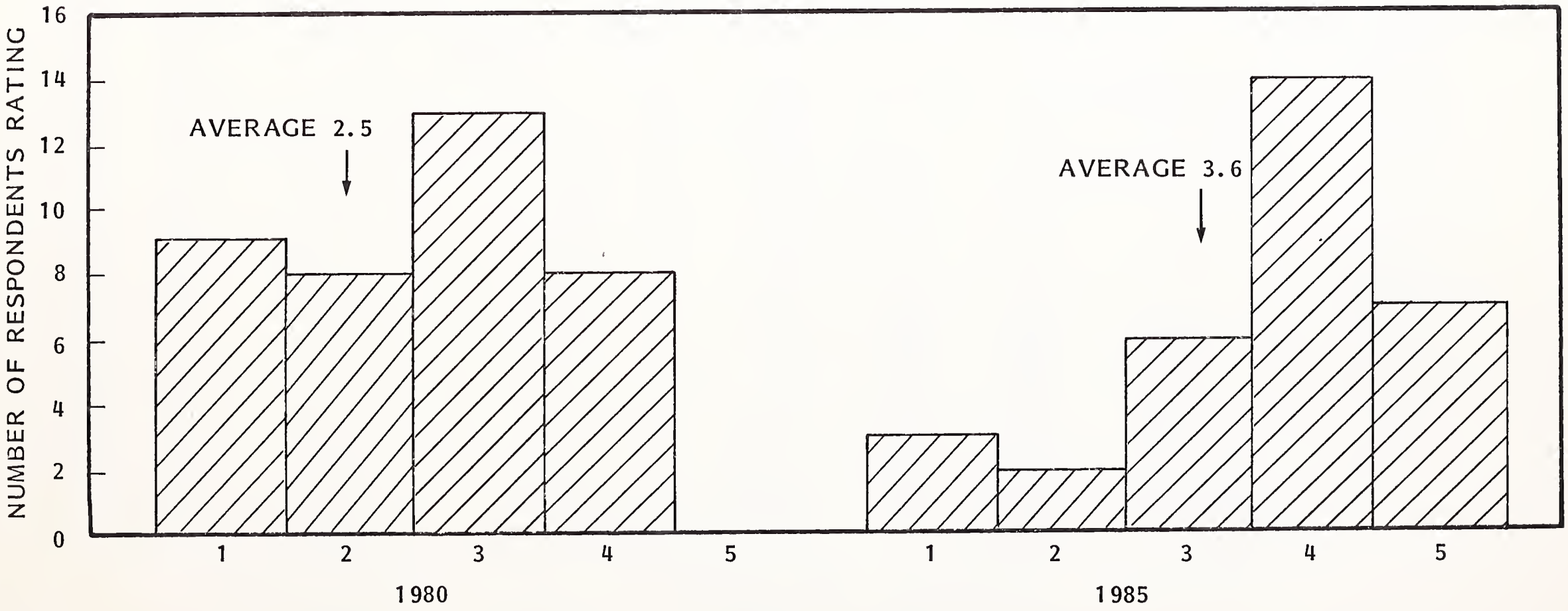
- The areas on which improvements in the CAD/VLSI design process from 1980 to 1985 are expected to focus are shown in Exhibit IV-6.

  - Improvements in the listed applications are expected to reduce the required skill level of I.C. layout designers.

  - This is a vital issue for an industry now dependent on a scarce group of about 2,000 highly skilled I.C. designers.

EXHIBIT IV-5

RESPONDENTS' OVERALL RATINGS
OF THE ADEQUACY OF CAD
APPLICATIONS AS A WHOLE -
1980-1985



NOTE: RATED ON A SCALE WHERE 5 IS COMPLETELY ADEQUATE AND 1 IS WOEFULLY INADEQUATE

EXHIBIT IV-6
EXPECTED IMPROVEMENTS IN THE
CAD/VLSI DESIGN PROCESS,
1980-1985,
AS REPORTED BY RESPONDENTS

- DESIGN RULES CHECKING
- SCHEMATICS
- TESTING
- FUNCTIONAL SIMULATION
- SKILL LEVEL OF IC LAYOUT DESIGNERS

C. MACHINE TIME AND LABOR BY APPLICATION

- Design labor and computer time expended for a typical VLSI design (microprocessor) are shown in Exhibit IV-7.

- The two basic design applications, I.C. layout and circuit and logic simulation, require enormous amounts of labor and computer time.

  - Labor is measured in person years.

  - Computer run time is measured in days or months.

  - Both applications are difficult to solve because they relate directly to VLSI complexity level.

  - Clearly, if these requirements were to increase proportionately to the expected 32 times increase in VLSI complexity over the next five years, the situation would be intolerable.

  - New methods must be developed through research efforts.

- Design rules checking is more amenable to solution even though it requires computer run times measured in days.

  - DRC is not as directly related to complexity as some of the other applications, and it does not require large amounts of labor.

- It is significant to note that respondents were unable to estimate labor and computer run times for either schematics or testing.

  - Even though these are vital applications for future VLSI design, they have not been addressed by the industry, and are just beginning to be defined.

EXHIBIT IV-7

DESIGN LABOR AND COMPUTER TIME
EXPENDED FOR A TYPICAL VLSI DESIGN (MICROPROCESSOR),
ESTIMATED FROM VARIED RESPONSES

APPLICATION	LABOR	COMPUTER RUN TIME	TYPE OF COMPUTER
DESIGN RULES CHECKING	3 PERSON WEEKS	20 HOURS	IBM MODEL 370-168
I.C. LAYOUT	2 PERSON YEARS	9 MONTHS	2 CALMA STATIONS
CIRCUIT AND LOGIC SIMULATION	1 PERSON YEAR	50 HOURS	IBM MODEL 370-168
SCHEMATICS	NO DATA	NO DATA	NO DATA
TESTING	NO DATA	NO DATA	NO DATA

- They are directly related to VLSI complexity and will be difficult to define and develop.

- However, INPUT believes that applications, schematics and testing represent a major market opportunity.

V MARKET ANALYSIS AND FORECAST

V MARKET ANALYSIS AND FORECAST

A. MARKET ANALYSIS AND FORECAST BY APPLICATION

- Respondents estimated the percentage of the total CAD/VLSI market attributable to each of the five major applications for 1980 and 1985.

  - This percent breakdown was applied to INPUT's revised estimate of the total CAD/VLSI market ($200 million to $1,660 million in 1985), including all modes of delivery, to determine the market by application. The results are shown in Exhibit V-1.

- Taken together, schematics and testing are expected to grow the most rapidly because of their importance for future VLSI design and their present embryonic state.

  - The estimated combined AAGR is 90%, almost twice that of the CAD/VLSI market itself.

  - These new applications are expected to account for 30% of the market in five years, an increase in the market of $480 million per year by 1985.

- Circuit and logic simulation are expected to grow at an AAGR of 60%, significantly more than the growth rate of the industry as a whole.

EXHIBIT V-1

PERCENT OF USER EXPENDITURES FOR VENDOR-SUPPLIED CAD/VLSI SYSTEMS BY MAJOR APPLICATION, 1980-1985, AS REPORTED BY RESPONDENTS (INCLUDES ALL MODES OF DELIVERY)

APPLICATION	USER EXPENDITURES				AAGR PERCENT
	1980		1985		
	PERCENT	$ MILLION	PERCENT	$ MILLION	
DESIGN RULES CHECKING	20%	$ 40	10%	$160	30%
I.C. LAYOUT	40	80	20	330	30
CIRCUIT AND LOGIC SIMULATION	30	60	40	670	60
SCHEMATICS	5	10	10	170	80
TESTING	5	10	20	330	100
TOTAL	100%	$200*	100%	$1,660*	50%

*INPUT FORECAST

- Simulation, making large processing demands, is expected to account for 40% of the market in five years, an increase in the market of $610 million per year by 1985.

- Design rules checking and I.C. layout, already further along in development, are both expected to grow at a rate significantly below the growth rate for the CAD/VLSI market as a whole.

  - The expected AAGR is 30%.

  - Taken together, these two applications are expected to account for 30% of the total market, down from an estimated 60% today.

  - The expected total market increase is 370 million per year by 1985.

B. MARKET ANALYSIS AND FORECAST BY MODE OF DELIVERY

1. MODE OF DELIVERY

- The three modes of delivery for CAD/VLSI systems, which are the focus of this forecast, are as follows:

  - Freestanding (turnkey) systems (minicomputer-based).

  - Large in-house host systems.

  - Remote computing systems.

- Respondents estimated the percentage of processing time for the total market and for each application by mode of delivery. The results are shown in Exhibit V-2.

EXHIBIT V-2

PERCENT OF CAD/VLSI PROCESSING
ACCOMPLISHED BY MODE OF DELIVERY FOR EACH APPLICATION, 1980-1985,
AS REPORTED BY RESPONDENTS

PERCENT / APPLICATION	1980 MODE OF DELIVERY				1985 MODE OF DELIVERY			
	T/K	I/H	RCS	TOTAL	T/K	I/H	RCS	TOTAL
DESIGN RULES CHECKING	60%	15%	25%	100%	60%	30%	10%	100%
I.C. LAYOUT	95	5	–	100%	95	5	–	100%
CIRCUIT AND LOGIC SIMULATION	15	40	45	100%	30	50	20	100%
SCHEMATICS	65	25	10	100%	55	40	5	100%
TESTING	55	25	20	100%	60	30	10	100%
OVERALL	60%	20%	20%	100%	55%	35%	10%	100%

T/K = FREESTANDING (TURNKEY) SYSTEMS (MINICOMPUTER-BASED)
I/H = LARGE IN-HOUSE HOST SYSTEMS
RCS= REMOTE COMPUTING SYSTEMS

- In determining the market, it was assumed that all three modes of delivery were cost competitive, and that processing time relates closely to user expenditures in the CAD/VLSI market.

- The breakdown of the total CAD/VLSI market by mode of delivery in 1980 is estimated to be 60% turnkey, 20% in-house and 20% RCS.

- By 1985, a shift toward in-house processing is expected as users choose to place new applications in-house rather than on RCS. The estimated breakdown is 55% turnkey, 35% in-house and 10% RCS.

- These breakdowns were used to extend INPUT's estimate of the CAD/VLSI market from turnkey systems to the total market, including all modes of delivery.

• A breakdown of user expenditures for vendor-supplied CAD/VLSI systems by mode of delivery for each application, 1980-1985, is shown in Exhibit V-3.

- The predominant mode of delivery for CAD/VLSI systems is expected to remain turnkey systems, reaching $910 million per year by 1985, and accounting for 55% of the market.

- The new applications, schematics and testing, taken together, are expected to reach $500 million per year by 1985, and to account for 30% of the market.

- The largest sector of the market in 1985 is expected to be simulation.

  . This is due to the large computers required for simulation. For instance, U.C. Berkeley's SPICE currently runs on AMDAHL machines.

  . The market for simulation is expected to reach $670 million per year by 1985, 40% of the total market.

EXHIBIT V-3

BREAKDOWN OF USER EXPENDITURES FOR VENDOR-SUPPLIED CAD/VLSI SYSTEMS
BY MODE OF DELIVERY FOR EACH APPLICATION, 1980-1985,
AS REPORTED BY RESPONDENTS

EXPENDITURES ($ MILLION) / APPLICATION	1980 MODE OF DELIVERY				1985 MODE OF DELIVERY			
	T/K	I/H	RCS	TOTAL	T/K	I/H	RCS	TOTAL
DESIGN RULES CHECKING	$ 24.0	$ 6.0	$10.0	$ 40.0	$ 95.0	$ 50.0	$ 15.0	$160.0
I.C. LAYOUT	76.0	4.0	-	$ 80.0	315.0	15.0	-	$330.0
CIRCUIT AND LOGIC SIMULATION	8.0	25.0	27.0	$ 60.0	208.0	345.0	117.0	$670.0
SCHEMATICS	6.5	2.5	1.0	$ 10.0	92.0	70.0	8.0	$170.0
TESTING	5.5	2.5	2.0	$ 10.0	200.0	100.0	30.0	$330.0
TOTAL	$120.0	$40.0	$40.0	$200.0	$910.0	$580.0	$170.0	$1,660.0*

T/K = FREESTANDING (TURNKEY) SYSTEMS (MINICOMPUTER-BASED)
I/H = LARGE IN-HOUSE HOST SYSTEMS
RCS= REMOTE COMPUTING SYSTEMS

*INPUT FORECAST

INPUT

. The predominant mode of delivery for simulation in 1985 is expected to be in-house systems, reaching $345 million per year.

. Simulation is also expected to be far and away the major market for RCS, reaching $117 million per year by 1985.

- I.C. layout, although not growing as rapidly as other applications, is expected to reach $330 million per year by 1985, and will remain almost exclusively turnkey.

- In summary, the breakdown of user expenditures for vendor-supplied CAD/VLSI systems by mode of delivery, total and AAGR 1980-1985, is shown in Exhibit V-4.

- By 1985, users expect that RCS will lose a significant percentage of market share to in-house systems, a user perception generally familiar to the RCS industry.

. Because of this, in-house systems are expected to be the fastest-growing sector of the market, with an AAGR of 71%.

. The growth rate in RCS is expected to be 34%, which is well below the expected 50% AAGR for the industry as a whole.

- The largest part of the total market is expected to be turnkey systems, with an AAGR of 50%, equal to the growth rate of the market as a whole.

2. IMPORTANCE OF OVERALL SYSTEM DESIGN

- Users felt that it is critically important for all applications to be integrated into an overall system design within the forecast timeframe.

EXHIBIT V-4

BREAKDOWN OF USER EXPENDITURES FOR VENDOR-SUPPLIED CAD/VLSI SYSTEMS BY MODE OF DELIVERY - TOTAL AND AAGR, 1980-1985

(IN $ MILLION)

YEAR / AAGR	T/K	I/H	RCS	TOTAL
1980	$120	$ 40	$ 40	$ 200*
1985	$910	$580	$170	$1,660*
AAGR	50%	71%	34%	53%*

T/K = FREESTANDING (TURNKEY) SYSTEMS (MINICOMPUTER-BASED)
I/H = LARGE IN-HOUSE HOST SYSTEMS
RCS= REMOTE COMPUTING SYSTEMS

*INPUT FORECAST

- Nine out of nine respondents rated the importance of system design to be 5 on a scale where 5 is critically important and 1 is unimportant.

- Systems integration is essentially independent of whether the system is supplied by one or more vendors.

- Compatibility is a key design feature.

- Industry data format and interface standards will be an issue.

VI THE HUMAN INTERFACE IN CAD/VLSI

VI THE HUMAN INTERFACE IN CAD/VLSI

A. GRAPHICS

- Respondents' ratings of the importance of graphics for CAD/VLSI applications are shown in Exhibit VI-1.

  - The importance of graphics depends on the application.

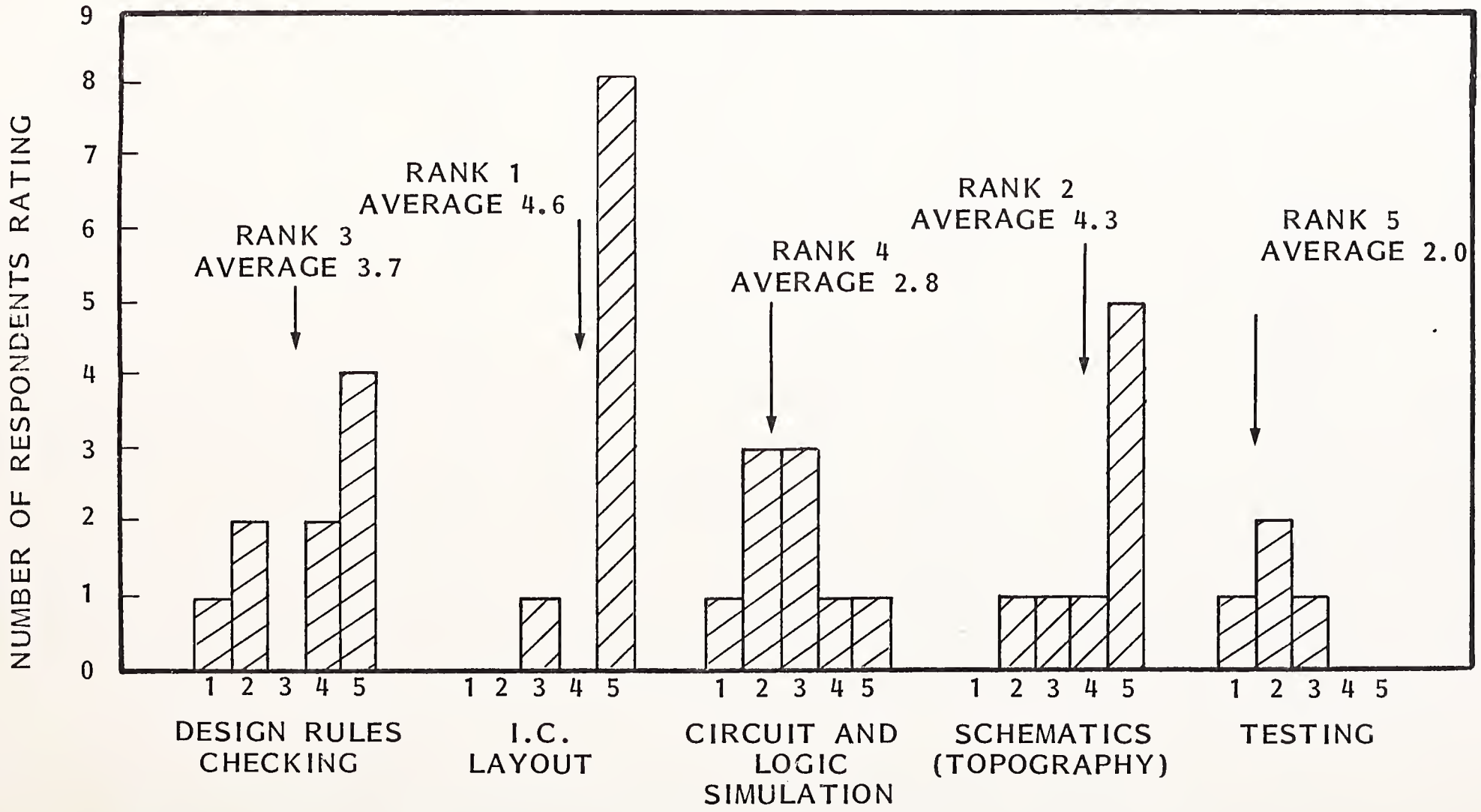
    . It is critically important for those applications where a major human interface is involved, like I.C. layout and schematics, and not very important for those applications that do not involve a major human interface, like circuit and logic simulation and testing.

- The following applications are ranked in order of the importance of graphics.

Rank	Application
1	I.C. layout
2	Schematics
3	Design rules checking
4	Circuit and logic simulation
5	Testing

EXHIBIT VI-1

RESPONDENTS' RATINGS OF THE IMPORTANCE
OF GRAPHICS FOR CAD/VLSI APPLICATIONS



NOTE: RATED ON A SCALE WHERE 5 IS CRITICALLY IMPORTANT AND 1 IS UNIMPORTANT

- Users are generally dissatisfied with the graphics available on present CAD/VLSI systems.

  - Five out of eight respondents do not believe that today's systems offer adequate graphics.

- Based on the premise that the VLSI design process over the next five years will become more automated, and that this will result in less designer time at the displays, users were asked to estimate whether the need for graphics would change with respect to its relative importance in CAD/VSLI systems.

  - Respondents unanimously rejected the premise as unsound, and stated that the need for graphics would increase.

  - One respondent expressed it this way:

    . "This is the same old pie in the sky that I have been hearing for ten years - someone is always going to come up with the super systems, but it never happens."

- INPUT believes that graphics are very important for CAD/VLSI systems in the forecast timeframe and that they must continue to be emphasized as an important design feature.

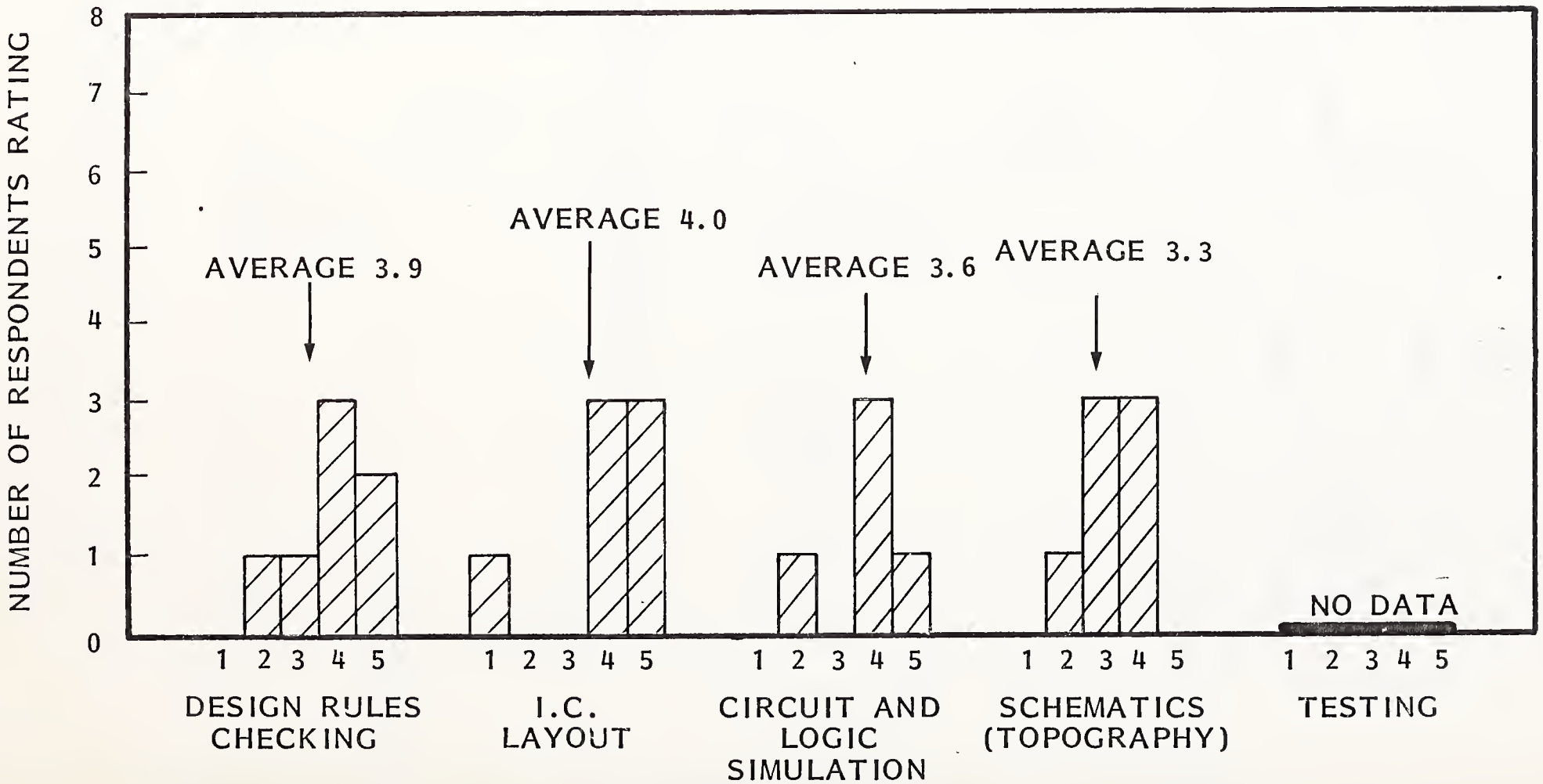
B. COLOR

- Respondents' ratings of the importance of color for CAD/VLSI applications are shown in Exhibit VI-2.

  - The ratings are all above average, indicating the importance of color in CAD/VLSI graphic displays, particularly for 1985 technology.

EXHIBIT VI-2

RESPONDENTS' RATINGS OF THE IMPORTANCE
OF COLOR FOR CAD/VLSI APPLICATIONS



NOTE: RATED ON A SCALE WHERE 5 IS CRITICALLY IMPORTANT AND 1 IS UNIMPORTANT

INPU

- Color is most critical for design rules checking and I.C. layout, and not as important for simulation, schematics and testing.

- Color is essential in future CAD/VLSI systems in order to be competitive.

- One respondent put the subject in perspective:

  . "Color is much more than a nicety, but also it is not fundamental."

C. RESPONSE TIMES

- Response times are a problem in today's CAD/VLSI systems and are likely to remain so in future systems in the forecast timeframe.

  - Eight out of nine respondents regarded response times in today's systems as inadequate, deeming them a serious problem.

  - Seven out of eight respondents felt that the problem would be more critical in the future.

- The response time problem relates to multiple users operating in a timesharing mode.

  - By entering a major application, one user can slow down system response for others, which:

    . Ruins the productivity of other designers.

    . Produces frustration.

- Makes for poor relationships between designers.
- Forces designers to work at odd hours.

- The problem is exaggerated by the fact that designers have an insatiable appetite for rapid response; any lag is always too long.
- The problem is a function of the trade-off between system costs and response time, but the problem has not been solved in today's systems and will most likely remain a problem in the 1985 timeframe.

VII SUPPORT REQUIREMENTS

VII SUPPORT REQUIREMENTS

A. CONSULTING

- For today's CAD/VLSI systems, and particularly for future systems where VLSI complexity is expected to double every year, it is essential that users have access to members of the vendor's professional staff.

  - The requirements far exceed normal field maintenance. Consulting help is needed from the "gurus" who really understand what goes on with the software.

- All respondents agreed that it was essential to their company that vendors of VLSI/CAD systems provide professional consulting services, and eight out of nine respondents felt that this should be in their local geographic area.

  - Not suprisingly, users find it much more satisfactory to solve systems problems with local professionals than to compete for attention and communication with professionals across the continent.

- Vendor-provided local consulting services will meet with a high degree of user acceptance. Typical comments from users are:

  - "Problems are difficult to solve remotely."

- "When you are in California, it is hard to compete for attention with vendors' professional staff located in New England."

- "You can't just drop these systems on our doorstep."

- "Bless the vendor who provides local professional services."

- "The vendor who sets up local professional consulting services will sell a lot of systems."

B. INDEPENDENT DESIGN CENTERS

- Respondents have a decidedly negative attitude toward the concept of independent design centers providing contract design services for VLSI products in the 1980 to 1985 timeframe.

  - Six out of nine respondents would not use the services of such design centers at all.

  - For those who felt that they would use the services of an outside design center, the extent of use was ranked only moderately on a scale where the highest rating was "buy all the outside time we could" and the lowest was "little use."

- INPUT would note, however, that the respondents for this study are an elitist group whose opinions on design centers are not likely to be representative of the views of the user community as a whole on this subject.

- The protection of proprietary rights for a product is a major problem in the use of independent design centers.

- Seven of eight respondents regarded it as a problem.

- The protection of proprietary rights is closely related to VLSI complexity.

  . If vendors had access to designs only at the subassembly level, the problem would be less severe.

- Today's VLSI devices contain an entire systems design, so the consequences of disclosure to others, or competitively selling similar devices, are much more severe.

- Typical comments from respondents are as follows:

  - "You need to develop your own competence."

  - "Ridiculous concept, if you have a computer scientist or design engineer on your staff, he must develop competence."

  - "You need to protect your design."

  - "It takes a $500 million company to do VLSI design."

  - "It takes large amounts of capital to set up VLSI design - small groups can't come up with it."

- The preponderant feeling (five out of nine) among respondents was that vendor-supplied independent design centers providing education, consulting, chips design and other technology support on a contract basis, would not be an important factor in the industry in the 1980-1985 timeframe.

  - The feeling is that if the concept goes at all, it is likely to attract business from small firms and would not be a major factor in the industry.

APPENDIX A: DATA BASE

EXHIBIT A-1

INTERVIEW PROGRAM -
USERS OF CAD/VLSI SYSTEMS

TYPE OF ORGANIZATION	NUMBER OF RESPONDENTS	ON-SITE / TELEPHONE
SYSTEMS COMPANY	2	1 / 1
COMPUTER MANUFACTURER	3	2 / 1
SEMICONDUCTOR PRODUCER	4	1 / 3
UNIVERSITY	1	1 / –
TOTAL	10	5 / 5

EXHIBIT A-2

BREAKDOWN OF USER EXPENDITURES FOR VENDOR-SUPPLIED CAD/VLSI SYSTEMS BY MODE OF DELIVERY - TOTAL AND AAGR, 1980-1985

(IN $ MILLION)

YEAR / AAGR	T/K	I/H	RCS	TOTAL
1980	$120	$ 40	$ 40	$ 200*
1985	$910	$580	$170	$1,660*
AAGR	50%	71%	34%	53%

T/K = FREESTANDING (TURNKEY) SYSTEMS (MINICOMPUTER-BASED)
I/H = LARGE IN-HOUSE HOST SYSTEMS
RCS= REMOTE COMPUTING SYSTEMS

*INPUT FORECAST

APPENDIX B: DEFINITIONS

APPENDIX B: DEFINITIONS

BATCH SERVICES This includes data processing performed at vendors' sites of user programs and/or data which are physically transported (as opposed to electronically by telecommunications media) to and/or from those sites. Data entry and data output services, such as keypunching and COM processing, are also included. Batch services include those expenditures by users which take their data to a vendor site which has a terminal connected to a remote computer used for the actual processing.

BYTE Approximately equivalent to the storage required for one alphanumeric character (i.e., one letter of number).

CENTRAL PROCESSING UNIT (CPU) The arithmetic and control portion of a computer; i.e., the circuits controlling the interpretation and execution of computer instructions.

COMPUTER SERVICES Those services provided by vendors which perform data processing functions using vendor computers, or assist users to perform such functions on their own computers.

DATA BASE MANAGEMENT SYSTEM A generalized computer program which handles the mechanics of storing, updating and accessing data for multiple applications. This definition does not include file management systems which are designed primarily for single applications (e.g., MARK IV, EASTRIEVE).

- DISTRIBUTED DATA PROCESSING (DDP)

  - INPUT was unable to find a consensus among both users and vendors as to a definition of DDP. It appears to be a concept that is uniquely structured to satisfy individual vendor and user requirements.

  - Nonetheless, as a result of extensive work in this area, INPUT offers the following hybrid definition:

    "Distributed processing is the deployment of programmable intelligence in order to perform data processing functions where they can be accomplished most effectively, through the electronic interconnection of computers and terminals, arranged in a telecommunications network adapted to the user's characteristics."

ELECTRONIC MAIL A range of services which transmit documents consisting of text and graphic material to be read by a person - the quality of the document will be high.

END USER May buy a system from the hardware supplier(s) and do its own programming, interfacing and installation. Alternately, it may buy a turnkey system from a systems house or hardware integrator.

EQUIPMENT COMPATIBILITY A service which allows information to be interchanged among equipment from different manufacturers, and among equipment of different types - terminals, facsimiles, and mainframes are all included.

FACILITIES MANAGEMENT (FM) (Also referred to as "Resource Management" or "Systems Management.") The management of all or part of a user's data processing functions under a long-term contract (not less than one year). To qualify as FM, the contractor must directly plan and control as well as operate the facility provided to the user on-site, through communications lines, or mixed mode. Simply providing resources, even though under a long-term contract and/or for all of a users' processing needs, does not necessarily qualify as FM.

GENERAL PURPOSE COMPUTER SYSTEMS A computer designed to handle a wide variety of problems; includes machine room peripherals, systems software, and small business systems.

INFORMATION PROCESSING Data processing as a whole including use of business and scientific computers.

INSTALLED BASE Cumulative number or value (cost when new) of computers in use.

MEAN TIME TO RESPOND The elapsed time between the user placement of a service call and the arrival at the user's location of a field engineer.

MEAN TIME TO REPAIR The elapsed time from the arrival of the field engineer on the user's site until the device is repaired and returned to the user for his utilization.

MEAN TIME BETWEEN FAILURES (MTBF) The elapsed time between hard failures on a device or a system.

MESSAGE A communication intended to be read by a person. The quality of the received document does not have to be high - only readable. Graphic material is not included.

MICROCOMPUTER Combines all of the CPU, memory and peripheral functions of a computer on a chip of silicon. It may be sold in an integrated circuit package or with the addition of more memory and peripheral circuits packaged on a board of a console. Eight bit computer on a chip used as a component.

MINICOMPUTER Usually a 12 to 16 bit computer which is provided with limited applications software and support and represents a portion of a complete, large system.

MULTIPLE DISTRIBUTION A message is transmitted to many locations either pre-selected or listed at time of transmission.

PERIPHERALS Includes all input, output, and storage devices, other than main memory, which are locally connected to the main processor and are not generally included in other categories, such as terminals.

PROCESSING SERVICES Processing services encompass FM, RCS, and batch services. They are categorized by type of service, as distinguised from mode of service, bought by users as follows:

GENERAL BUSINESS services are processing services for applications which are common to users across industry categories. Software is provided by the vendor; this can be a complete package, such as a payroll package, or an application "tool," such as a budgeting model, where a user provides much of the customizing of the finished product it uses. General business processing is often repetitive and transaction oriented.

SCIENTIFIC AND ENGINEERING services are the processing of scientific and engineering problems for users across industries. The problems usually involve the solution of mathematical equations. Processing is generally problem solving and is non-repetitive, except in the sense that the same packages or "tools" are used to address different, but similar problems.

INDUSTRY SPECIALTY services provide processing for particular functions or problems unique to an industry or industry group. The software is provided by the vendor either as a complete package or as an application "tool" which the user employs to produce its unique solution. Specialty applications can be either business or scientific in orientation; data base services where the vendor supplies the data base and controls access to it (although it may be owned by a third party) are also included under this category. Examples of industry specialty applications are: seismic data processing, numerically-controlled machine tool software development, and demand deposit accounting.

UTILITY services are those where the vendor provides access to a computer and/or communications network with basic software that enables any user to

develop its own problem solution or processing system. These basic tools include terminal handling software, sorts, language compilers, data base management systems, information retrieval software, scientific library routines, and other systems software.

DBMS REVENUES include all revenues directly relating to the processing and storing of data which interacts with the data base management system, as well as programming and training charges related to DBMS application development and usage. Not included as DBMS revenues are pull-through revenues, such as processing charges for the use of other software to manipulate data extracted from the data base management system, or revenue obtained from operating a data base management system purchased by one customer and run exclusively for him.

DATA BASE MANAGEMENT SYSTEM SERVICE provides to a user, for a fee, a data base management system through a Remote Computing Service (RCS).

PROPRIETARY DBMS is a DBMS developed by the RCS vendor or acquired from an external group not actively marketing it as a software product.

THIRD PARTY DBMS is a DBMS developed by someone other than the RCS vendor and marketed by that of another organization as a software product.

PROPRIETARY DBMS VENDOR is one which has a majority of its DBMS revenues from Proprietary DBMS.

THIRD PARTY DBMS VENDOR obtains a majority of its DBMS revenues from Third Party DBMS

PROFESSIONAL SERVICES Management consulting related to EDP, systems consulting, systems design and programming, and other professional services are included in this category. Services can be provided on a basis of: "Time and Materials," whereby the user pays for the time used of an individual on a daily or other fixed rate, or "Fixed Price," where the user pays a fixed fee for a specific task or series of tasks.

REMOTE COMPUTING SERVICES (RCS) Provision of data processing to a user by means of terminals at the user's site(s) connected by a data communications network to the vendor's central computer. There are three sub-modes of RCS:

INTERACTIVE (timesharing) is characterized by interaction of the user with the system, primarily for problem solving timesharing, but also for data entry and transaction processing; the user is "on-line" to the program/files.

REMOTE BATCH is where the user hands over control of a job to the vendor's computer which schedules job execution according to priorities and resource requirements.

DATA BASE is characterized by the retrieval of information from a vendor-maintained data base. This may be owned by the vendor or a third pary.

REMOTE COMPUTING SERVICES (RCS) REVENUES are those revenues obtained by the provision of data processing to a user by means of a terminal at the user's site(s). The terminal is connected by a data communications network to the vendor's central computer. Not included as RCS revenues are sales to captive companies (i.e., companies which are part of the same corporate entity as the vendor).

SIC Standard Industrial Classification. Developed for use in classifying establishments by type of activity to facilitate and promote uniformity, as well as comparability, in the collection and presentation of statistical data on economic activities.

SMALL BUSINESS COMPUTER For the purpose of this study, it is a system which is built around a Central Processing Unit (CPU), and which has the ability to utilize at

least 20M bytes of disk capacity, to provide multiple CRT work stations, and to offer business-oriented system software support. Minicomputer based system used for general business data processing and for specialized industry oriented business applications.

SOFTWARE Computer programs.

SOFTWARE PRODUCTS This category is for users' purchases of systems and applications packages for use on in-house computer systems. The figures quoted include lease and purchase expenditures, as well as fees for work performed by the vendor to implement and maintain the package at the users' sites. Fees for work performed by organizations other than the package vendor are counted in professional services. There are two sub-categories:

> SYSTEMS PACKAGES OR SYSTEMS SOFTWARE are operating systems, utilities, and languages routines that enable the computer/communications system to perform basic functions. This software is provided by the mainframe manufacturers with their hardware; other vendors provide improved versions of this and special-purpose routines. This classification includes compilers, data base management software, diagnostic software, and sorts.
>
> APPLICATIONS PACKAGES OR APPLICATIONS SOFTWARE are software which perform processing to serve user functions. They consist of general purpose packages, such as accounting and inventory control, and special purpose packages, such as personal trust, airline scheduling, and demand deposit accounting.

SYSTEMS ANALYST Individual who analyzes problems to be converted to a programmable form for application to computer systems.

SYSTEMS HOUSE Integrates hardware and software into a total turnkey system to satisfy the data processing requirements of the end user. It may also develop system software products for license to end users.

- USER SITE HARDWARE SERVICES (USHS)

  - Place intelligent hardware (i.e., terminals, microcomputers, minicomputers) at the user's site or at the vendor's site dedicated to the user.

  - Offer significant RCS vendor-supplied software for execution on vendor-supplied intelligent hardware.

  - Offer user access to the RCS vendor's communications network.

  - Offer user access through the vendor's RCS networks to the vendor's mainframes or other intelligent hardware supplied to the user by the vendor.

VALUE ADDED NETWORK (VAN SERVICES) are the regulated communications network services that offer more than simple point-to-point connections.

APPENDIX C: QUESTIONNAIRE

CATALOG NO. YCDD

COMPUTER AIDED DESIGN METHODS FOR VLSI

In this study, present computer aided design methods for VLSI circuitry will be examined in detail and expected changes from 1980-1985 identified.

1. We would like for you to describe the design process for a product the complexity of a micro-processor, and indicate how this process may change by 1985.

   A. Do you start with an overall ARCHITECTURAL design step?

   ☐ Yes ☐ No

   What does it include? (Architecture, Micro-Architecture System, Test-Chip Design)

   Comment: _____

   _____

   B. Is the next step a detailed design step?

   ☐ Yes ☐ No

   What does it include?

   Comments: _____

   _____

   _____

   C. Design verification is obtained through CIRCUIT and LOGIC SIMULATION.

   Comment: _____

   _____

   _____

D. I. C. LAYOUT is made.

Comment: _____

_____

_____

E. The layout is checked for conformity with design rules - DESIGN RULE CHECKING - also the layout is compared to the external SCHEMATIC to assure that they are equivalent. The lines on the layout are checked - YELLOW LINING. Final verification of the layout is established.

Comment: _____

_____

_____

F. Test Generation.

Comment: _____

_____

_____

G. The pattern is generated - PATTERN GENERATION - and the tape sent to the mask shop where the mask is produced.

The mask is inspected for defects and a sample chip is produced.

Comment: _____

_____

_____

H. A wide range of device testing - ELECTRICAL TESTING.

Comment: _____

_____

_____

INPU

I. Design errors are corrected.

Comment: _____

_____

_____

How far back in the process do you go?

Comment: _____

_____

_____

J. How much on-going design for advanced features and manufacturing cost reduction is required?

Comment: _____

_____

_____

How far back in the process do you go?

Comment: _____

_____

_____

The most important CAD applications used in the above design process are:

- Design rule checking
- I.C. layout
- Circuit and logic simulation
- Schematics
- Testing

These will be used as the focus for this study.

Comment: _____

_____

_____

2. Do you see this design process changing between 1980 and 1985?

Why? _____

_____

_____

_____

_____

3. What is your overall impression of the adequacy of today's CAD technology for today's VSLI circuitry and expected adequacy of 1985 CAD technology for 1985 VLSI circuitry.

Comment: _____

_____

_____

4. Please rate on a scale of 1 to 5, where '5' is completely adequate and '1' is woefully inadequate and also rank in order of priority the following CAD applications.

Application	1980		1985	
	Rating	Ranking	Rating	Ranking
• Schematics	_____	_____	_____	_____
• Circuit and Logic Simulation	_____	_____	_____	_____
• I.C. Layout	_____	_____	_____	_____
• Design Rules Checking	_____	_____	_____	_____
• Testing	_____	_____	_____	_____

5. For a typical design job, how much labor is expended and how much computer time is needed for each application?

Application	Labor		Run Time		Type of Computer	
	1980	1985	1980	1985	1980	1985
• Design Rule Checking						
• I.C. Layout						
• Circuit and Logic Simulation						
• Schematics						
• Testing						

6. Please rate, on a scale of 1 to 5, where '5' is of critical importance and '1' is unimportant, the use of graphics for each application; and rank the applications in the order of the importance of graphics.

Applications	Rating	Ranking
• Design Rule Checking		
• I.C. Layout		
• Circuit and Logic Simulation		
• Schematics		
• Testing		

7. Do you believe that today's CAD systems offer adequate graphics?

☐ Yes ☐ No

Comment: _____

_____

_____

8. As VLSI design becomes more automated over the next five years and time at the displays becomes less in a relative sense, do you believe that the need for graphics will:

☐ Increase

☐ Remain the same

☐ Decrease

in a relative sense?

Why? _____

_____

_____

_____

9. Please rate on a scale of 1 to 5, where '5' is critically important and '5' is unimportant, the need for color for each application. Also rank the applications in the order of the importance of color.

Application	Rating	Ranking
• Design Rule Checking	____	____
• I.C. Layout	____	____
• Circuit and Logic Simulation	____	____
• Schematics	____	____
• Testing	____	____

10. Are response times generally satisfactory in today's CAD systems or are they a problem?

☐ Satisfactory

☐ Are a Problem

If they are a problem, please comment on the applications in which response times are most critical.

Comment: _____

_____

_____

_____

_____

11. Do you feel that adequate response times will become more critical as VLSI complexity becomes greater in the next five years?

☐ Yes ☐ No

Comment: _____

_____

_____

12. What will be the percentage mix of user expenditures for vendor supplied VLSI CAD systems broken by application in 1980 and 1985?

Application	User Expenditures - Percent	
	1980	1985
• Design Rule Checking		
• I.C. Layout		
• Circuit and Logic Simulation		
• Schematics		
• Testing		
• All Other		
TOTAL	100%	100%

13. Please estimate what percent of CAD/VLSI processing is/will be accomplished by each of the three modes of delivery listed below, in total and for each application; in 1980 and 1985.

Application	1980 Mode of Delivery				1985 Mode of Delivery			
	T/K	I/H	RCS	Total	T/K	I/H	RCS	Total
• Design Rule Checking				100%				100%
• I.C. Layout				100				100
• Circuit and Logic Simulation				100				100
• Schematics				100				100
• Testing				100				100
• All Other				100				100
TOTAL				100				100

T/K = Free-standing (Turnkey) systems (mini-computer based)

I/H = Large In-house host systems

RCS = Remote computing systems

14. How important, on a scale of 1-5, where '5' is critically important and '1' is unimportant, is it for the applications to be integrated into an overall system design?

Rating _____

15. Do you believe that vendor supplied independent design centers providing education, consulting, chips design and other technology support on a contract basis will be an important factor in the industry in the 1980-1985 time frame?

☐ Yes ☐ No

Why? _____

_____

_____

_____

16. Would you company use the services of such design centers?

☐ Yes ☐ No

17. Would the protection of proprietory rights in the product be a major problem to your company in using such design centers?

☐ Yes ☐ No

Comment: _____

_____

_____

18. If your company were to use the services of such design centers, how extensively would you use them?

☐ Buy all the outside design time we could.

☐ Make extensive use.

☐ Moderately.

☐ Little use.

19. Is it important to your company that vendors of VLSI CAD systems provide professional consulting services in your geographic area?

☐ Yes ☐ No

Why? _____

_____

_____

_____

_____